Movable B

RIDGES

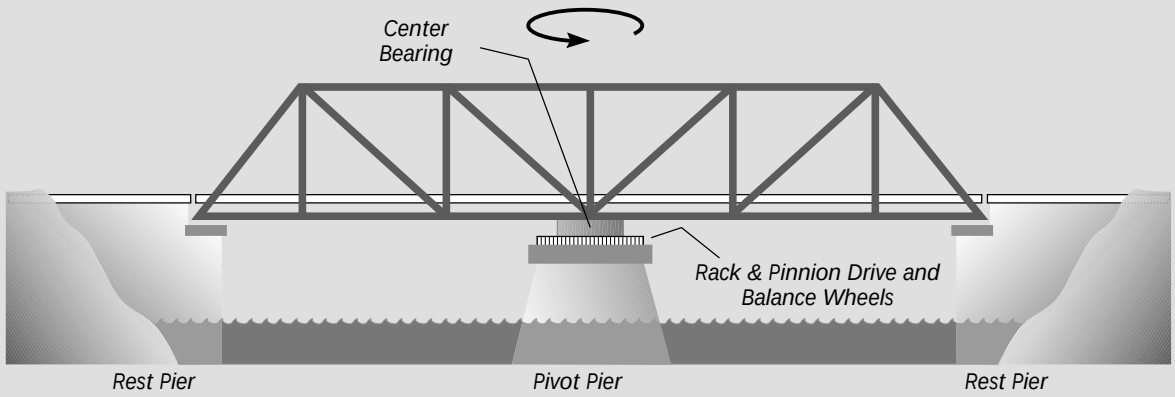
Delaware, with its coastline and numerous waterways, has a long history of movable bridges. By the early 19th century, increased vehicular traffic justified the construction of bridges over navigable waterways to replace ferries and circuitous roads.

Movable bridges are those that can be lifted or rotated to allow the passage of marine traffic. Movable bridge technology dates from ancient times, with the earliest documented examples represented by simple draw bridges that were hinged at one end and lifted at the other end by an outhaul line. The movable bridge remained in its primitive stage until the late-19th century after which the bridge type progressed rapidly due to advances in mechanical, electrical and civil engineering. In the United States, the same need for accommodating greater capacity and span lengths that spawned the railroad's great era of experimentation with metal truss bridges had a similar affect on movable bridge technology. In the last quarter of the 19th century, movable bridge technology entered the modern era that was dominated initially by swing span bridges and after the early 1890s by bascule (a French word meaning balance) bridges.

Delaware, with its coastline and numerous navigable waterways, has a long history of movable bridges. In the colonial and early republic periods, Delaware's economically important communities were established on navigable streams because of the reliance on waterborne trade and transportation. By the early 19th century, however, increased vehicular traffic justified construction of bridges over navigable waterways to replace ferries and circuitous

LEFT: The Lewes bascule bridge opens for a ship under way in the Lewes-Rehoboth Canal, ca. 1927. The bridge was one of several Scherzer rolling lift bridges constructed in the state during the 1920s. The bridge on what is now US Route 9 Business has since been replaced, but examples of patented Scherzer bascules still exist in Laurel (State Bridge S-152) and Milford (State Bridge K-21A).

Swing Span Bridge



Elevation of typical center-bearing swing span bridge.

roads around navigable streams. Since by law and tradition marine traffic holds right-of-way over roadway traffic, low bridges over navigable streams had to have movable spans to clear the marine channel for the passage of ships.

One of the first movable bridges in Delaware was built in Wilmington to carry South Market Street over the Christina River. Constructed in 1808, it was a wooden “turn bridge” or swing span. Other early movable bridges were located over the Christina River at Newport, the Nanticoke River at Seaford, and the Broad Creek at Laurel. The construction of the Chesapeake and Delaware Canal from 1804 to 1828 resulted in several movable bridges to carry old highways over the man-made waterway.

Ten movable highway bridges in Delaware that were built between 1915 and 1957 still survive. Most service crossings that have been in use since the 18th or first half of the 19th century, and in many instances, they are the second, third, or even fourth, successive movable bridge at the crossing. Because all of Delaware's surviving movable highway bridges date after 1910, their design was heavily influenced by late-19th and early 20th century engineering and technological advances. They are historically significant as examples of period technology. The majority of surviving movable highway bridges were constructed under the auspices of the Delaware State Highway Department as part of its program to modernize the state highway system.

Swing Span Bridges

A swing span bridge rotates in a horizotal plane around a vertical axis to a position parallel with the marine channel. When in operation, the movable span is supported in one of two methods; center bearing on a vertical pin or pivot, or rim bearing on a circular girder called a drum, which in turning moves on rollers. The rim bearing design was used for wider and heavier movable spans. All Delaware examples are the lighter and more easily designed, operated, and maintained center bearing design. The superstructure of swing span bridges can be trusses or girders, and historically they reflected the prevailing practices of fixed bridge construction with the specific type and design matched to the length and capacity needed at the crossing.

Swing span bridges are rotated by a series of reducing gear sets and a rack and pinion drive. The operator houses with the con-

Late-19th Century Swing Span Bridges

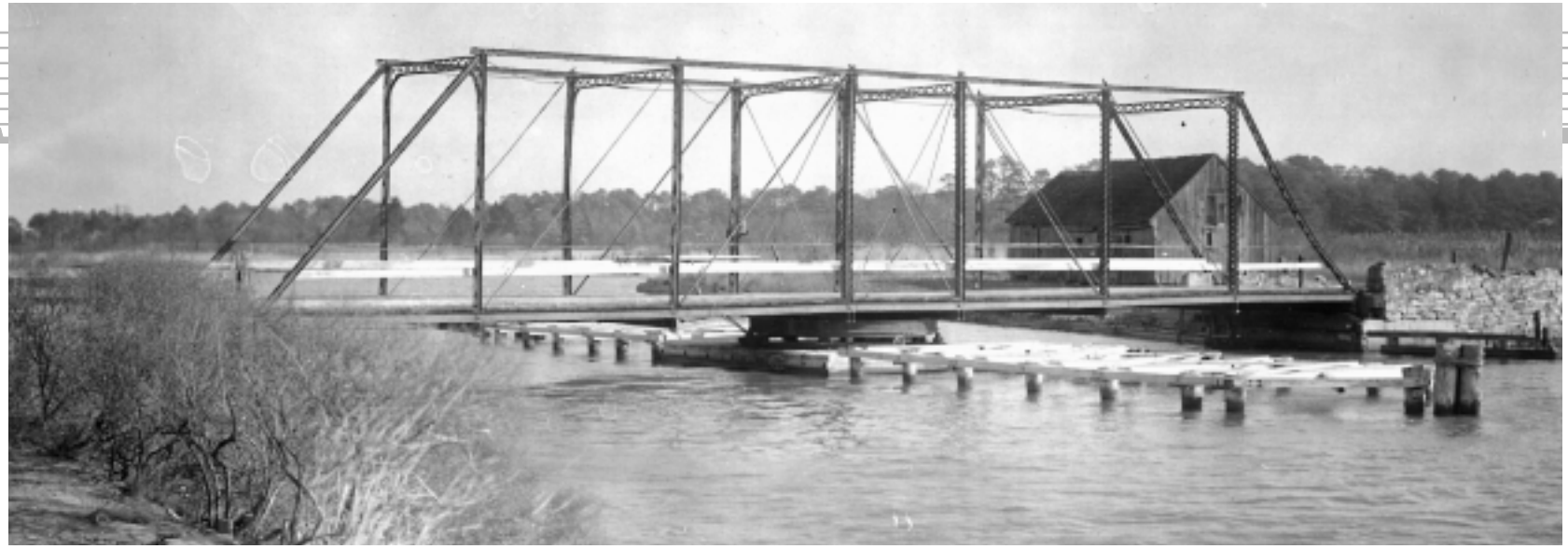
Fennimore's New Bridge (above) and Fennimore's Old Bridge (left), swing span bridges with metal truss superstructures, once carried Thomas Corner Road (State Route 9) over the Appoquinimink River's north and south channels at Fennimores, east of Odessa.

trols and machinery are located adjacent to or on the bridge, depending on its size. Many light swing span bridges were operated manually by cranks, but larger ones were first powered by steam engines and later by direct current electric motors.

Swing span bridges were known in Europe since at least the 17th century. Spurred by railroad expansion and the advances in metallurgy and bridge engineering, the bridge type developed most rapidly between 1840 and 1890 in this country. Historic photographs show that most swing spans built in the late-19th and early 20th centuries in Delaware were center bearing and had pony truss or thru truss superstructures.

Delaware's oldest surviving movable highway bridge is the 1915 Poplar Street bridge over Broad Creek in Laurel, Sussex County (State Bridge S-161). The swing span bridge is center bearing with a Warren pony truss superstructure. Although now fixed so that

The Blackbird Landing bridge over Blackbird Creek (left) was a variation of swing span bridge with a center tower and cable stays to support the span's free ends in the open position. Similar bridges once spanned over Cedar Creek at Slaughter Beach and the Christina River at Newport. None have survived.



The Broadkill River swing span bridge near Milton went the way of many bridges of its type in the early 20th century; it was replaced by a bascule bridge in the 1920s.

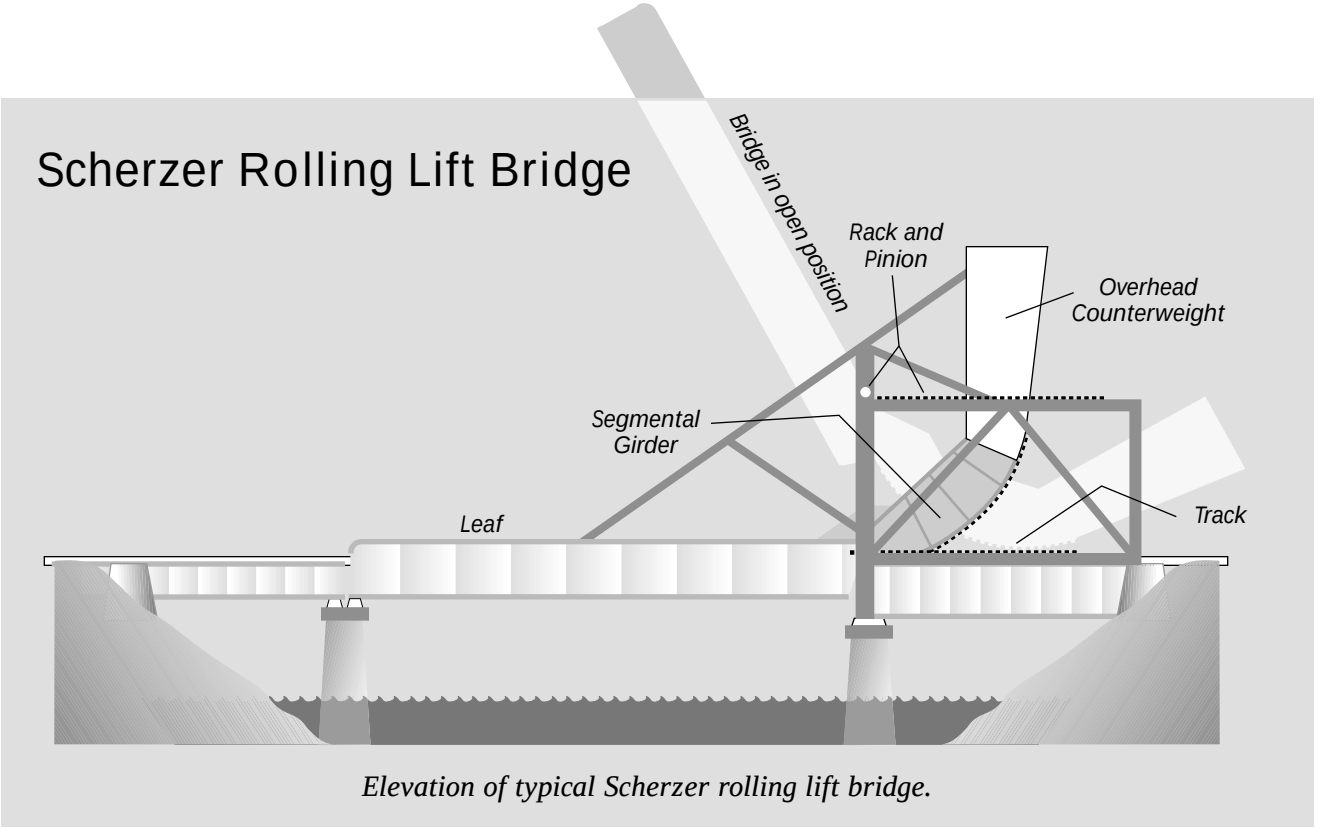
it does not open, the center pivot is still in place. The technology is also represented by several surviving railroad bridges including the state-owned 1916 bobtail (pivot not centered so that heel and toe portions are different lengths) swing span bridge on the Georgetown-Lewes line of the former Delaware, Maryland, & Virginia Railroad over the Lewes-Rehoboth Canal. This center bearing design bridge is still operable.

The demise of swing span bridges in Delaware, as well as elsewhere in the nation, resulted from the basic problem that the movable span and pivot pier are obstructions to navigation. Across smaller waterways, this problem was sometimes economically solved by a bobtail swing span where the pivot pier was placed adjacent to the stream bank rather than the middle of the channel. The swing span's longer arm was balanced by a counterweight in the shorter arm. In the 1890s, however, American engineers developed several alternatives to swing span technology, most notably the vertical lift and bascule bridge types. By 1910, most engineers preferred the bascule over all other movable bridge types. Historic plans and photographs preserved in state agencies and historical societies show that most of Delaware's 20th-century bascule bridges were built to replace truss swing spans.

Bascule Bridges

A bascule bridge rotates in a vertical plane around a horizontal axis, much like a seesaw. Although the bascule bridge type dates to ancient times, it was not until the 1890s that American engineers successfully developed bridge and operating mechanism designs that offered rapidity of operation and the ability to move long spans vertically achieving unobstructed marine channels. In comparison to swing span bridges, bascule bridges did not require a clear turning radius that prohibited the construction of docks adjacent to the bridge site, a particular concern in crowded urban waterfronts.

The beginning of the modern era of the bascule bridge in this country is traditionally held to be the successful completion in 1893 of the Van Buren Street bridge in Chicago, a rolling lift bascule bridge developed and patented by William Scherzer (1858-1893). The bridge was a significant milestone in bascule technology as it was the first movable design that quickly rotated a span of significant length and weight



Elevation of typical Scherzer rolling lift bridge.

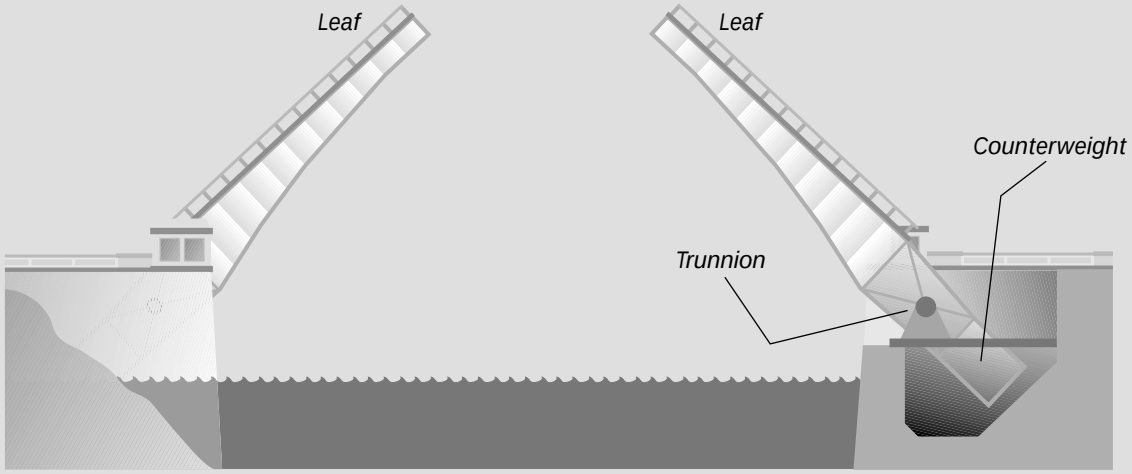
up and out of the shipping channel. In a rolling lift bascule bridge, the center of rotation continually changes and the center of gravity of the rotating part moves in a horizontal line, thereby shifting the point of application of the load on the pier. The movable leaf rolls back on segmental girders on the heel ends. The girder is matched to a track affixed to the top of the substructure or approach span. The most common Scherzer design is that with an overhead counterweight, but it also was built with an underneath counterweight. The Scherzer design was favored greatly by the railroads into the second decade of this century, but it also occasionally was used for highway bridges.

The Scherzer patents were managed by the Scherzer Rolling Lift Bridge Company of Chicago, an engineering firm that designed its bridges but contracted out bridge fabrication and construction. Over 175 Scherzer bridges were built nationwide before World War I. The Scherzer company continued to operate until the late 1930s, but by the early 1920s their major patents had expired, and several employees left the company to set up competing firms designing Scherzer-type bascules.

Delaware's two Scherzer rolling lift bascule highway bridges are the 1923 Central Avenue bridge in Laurel, Sussex County (State Bridge S-152) designed by the Scherzer company, and the 1929 Rehoboth Road over Mispillion River bridge in Milford, Kent County (State Bridge K-21A), designed by Charles L. Keller and H. P. Harrington, two former Scherzer company employees. The Scherzer rolling lift bascule bridge is the only patented type of bascule highway bridge represented in Delaware.

Scherzer was only a few years ahead of competitors such as Thomas E. Brown, Max

Doudle-Leaf Bascule Bridge



Elevation of typical double-leaf simple trunnion bascule bridge, illustrated in the open position.

G. Schinke, Theodore Rall, and Joseph B. Strauss, who also developed and patented popular bascule bridge designs. Each engineer patented a movable bridge design that had advantages and limitations, but acceptance of one patented design over another seems to have been as much a consequence of local preference, economics, and regional variation as strict engineering merits. In the case of Delaware's Scherzer rolling lift bascule bridges, state bridge engineer Arthur G. Livingston traveled to Chicago in 1923 meeting with Charles L. Keller, chief engineer of the Scherzer Company. The Delaware State Highway Department hired Keller as consulting engineer for at least six bascule bridges from 1923 to 1930.

While the patented bascule bridge types enjoyed a period of success from the 1890s to the early 1920s, they were eventually eclipsed by the simple trunnion bascule bridge, an unpatented design first advocated by the city of Chicago engineering department. In 1902, Chicago completed its first simple trunnion bascule bridge. Unlike the rolling lift bascule, the center of rotation on a simple trunnion bascule remains fixed and is placed near or at the center of gravity of the movable leaf. A horizontal steel pivot, called a trunnion, supports the entire weight of the bridge when it is in operation or in the open position. The counterweight, which serves to balance the long end with the shorter, heel end, is attached at the heel end. The simple trunnion bascule was a response to some of the functional deficiencies of the Scherzer rolling lift type, especially the fact that the shifting of the center of gravity as the bridge operated sometimes caused deformation of the segmental girder and track system, as well as increased stress on the substructure.

Between 1903 and 1910, Chicago went on to build eight other highway bascule bridges of the simple trunnion design. Frequently featured in period technical literature, the terms “simple trunnion bascule” and “Chicago Type Bascule” eventually became synonymous.

In Delaware, the simple trunnion bascule bridge was the dominant movable type after the mid 1920s. Six of the ten surviving movable highway bridges are simple trunnion bascule bridges built between

Early 20th Century Bascule Bridges

1924 and 1957. Although designed by four different engineering firms, Delaware's simple trunnion bascule bridges are remarkably similar and very recognizable descendants of the original Chicago design. The Delaware State Highway Department turned to a consulting engineer known nationally for expertise with movable bridges for each of them. Whether single leaf or double leaf, the bridges have deck or thru girder superstructures and fixed concrete counter-weights. Moderne-style operator and mechanical houses are standard, as is electric-powered operation. The similarity of Delaware's simple trunnion bascule bridges is an indication of how pervasive the type was by 1930, primarily because it was by far the easiest to design, build, and maintain.

The oldest simple trunnion bascule bridge in the state is the 1924 Front Street bridge in Seaford, Sussex County (State Bridge S-151), a single leaf bascule bridge designed by the Chicago Bascule Bridge Company. It is followed in age by four bridges in New Castle County: the 1927 South Market Street bridge over the Christina River in Wilmington (State Bridge NC-688); the 1929 James Street bridge over the Christina River in Newport (State Bridge NC-159); the 1932

The State Route 9 over the Chesapeake & Delaware Canal Channel Branch bridge (above) in Delaware City is a double-leaf single trunnion bascule bridge built in 1933. Owned by the U.S. Army Corps of Engineers, it was sealed and rendered inoperable in 1971. Larger ships now exclusively use the canal's main channel, enlarged in 1935. The Broadkill River bridge (left) near Milton was a Scherzer rolling lift bridge designed by Keller & Harrington of Chicago in the mid 1920's. It no longer exists. Because of the high cost associated with operating and maintaining movable bridges, as well as traffic delays caused by bridge openings, many of Delaware's early 20th century movable bridges have been fixed or sealed, or replaced by high level fixed span bridges.

The Locations of Delaware's Historic Movable Bridges

1. Poplar St. over Broad Creek
State Bridge S-161
Laurel, Sussex County

2. Central Ave. over Broad Creek
State Bridge S-152
Laurel, Sussex County

3. DM & V Railroad Bridge
Number 38.71
Lewes, Sussex County

4. Front St. over Nanticoke River
State Bridge S-151
Seaford, Sussex County

5. Rehoboth Rd. over Mispillion River
State Bridge K-21A
Milford, Kent County

6. North Church St. over Brandywine River
State Bridge NC-577
Wilmington, New Castle County

7. South Market St. over Christina River
State Bridge NC-688
Wilmington, New Castle County

8. Walnut St. over Christina River
State Bridge NC- 687
Wilmington, New Castle County

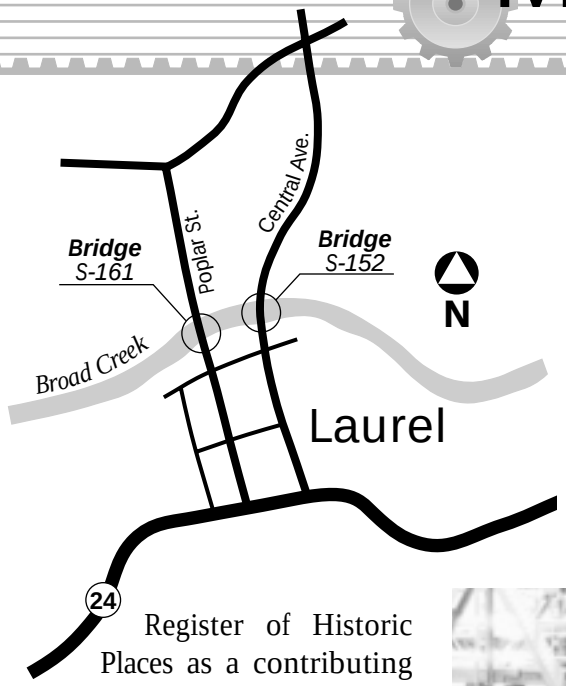
North Church Street bridge over the Brandywine River in Wilmington (State Bridge NC-577); and the 1933 State Route 9 over Chesapeake & Delaware Canal Branch in Delaware City (State Bridge NC-497), the latter owned by the U.S. Army Corps of Engineers. The 208'-long, double leaf South Market Street bridge remains operable, but the James Street, North Church Street, and State Route 9 bridges are not operable, having been sealed and much of the operating machinery removed.

The newest and longest of Delaware's movable bridges, the 276'-long Walnut Street bridge built in 1954-1957 over the Christina River in Wimington (State Bridge NC-687), marks the end of the era of bascule bridges. Because of the high cost associated with operating and maintaining movable bridges as well as traffic delays caused by bridge openings, high level, fixed span bridges were preferred after World War II.

In 1954, Delaware's Chief Highway

The Central Avenue bridge in Laurel is a patented Scherzer rolling lift bascule bridge, constructed in 1923.

Engineer Richard A. Haber commented that the state highway department would have rather built a high-level bridge for the new Walnut Street crossing, but that the high price of land acquisition had prevented that option. In the future, the department pursued replacing movable bridges with fixed spans. They also fixed or sealed older movable bridges across formerly navigable waterways when permitted to do so by the U.S. Army Corps of Engineers. For instance, in 1975, the Corps permitted the highway department to close to navigation the Popular Street (State Bridge S-161) and



The Poplar Street Bridge (above) is Delaware's only remaining pre-1956 swing span highway bridge.

This detail of the pivot pier (left) shows the rack and pinion, balance wheels, and center pivot floorbeams

the Central Avenue (State Bridge S-152) bridges over Broad Creek in Laurel after shipping on the stream had declined to negligible levels.

Poplar Street *(Road 28A)* over Broad Creek

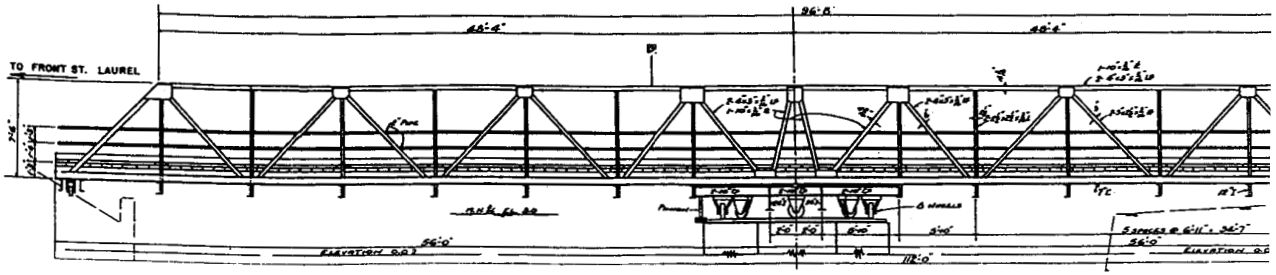
State Bridge S-161
Laurel, Sussex County
Designer/Builder: Unknown

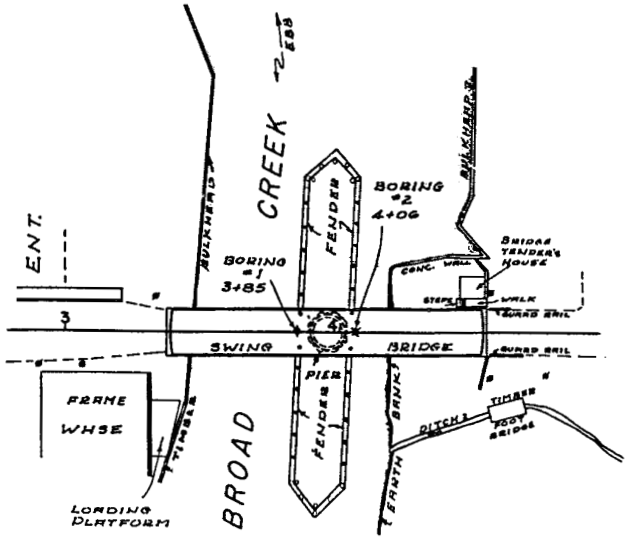
1915

The Poplar Street bridge is a 112'-long, 17'-wide, center-bearing, swing span bridge with a Warren pony truss superstructure. Constructed in 1915, the Poplar Street bridge is Delaware's oldest movable highway bridge. Currently, it is inoperable, although the turning mechanism remains in place. The bridge was operated manually by turning a capstan to engage the rack and pinion mounted on the center pivot pier. The bridge is listed in the National Register of Historic Places as a contributing resource to the Laurel Historic District, once an important rural commercial center with waterfront warehouses and canneries.

Swing span bridges were the dominant movable bridge type in Delaware from the 1870s to the 1910s. The Poplar Street bridge, when built in 1915, was a late example of the movable bridge technology that had been standard for several decades and was being rapidly superseded by the new bascule technology.

The bridge pivoted on a center bearing post with eight balance wheels traveling on a circular rack for stability. The Warren pony truss superstructure is composed of standard built-up steel angle and channel sections. Warren pony trusses were a popular early 20th century highway bridge type and were applied to both movable and fixed spans. Two rail high pipe railings are attached to the inside of the trusses. The bridge is supported on concrete abutments





Excerpts from 1946 repair plans to the Poplar Street bridge.

and a timber pile center pivot pier.

Little is known about the history of the Poplar Street bridge. Presumably it was constructed under the auspices of the Sussex County Levy Court. It was taken over by the Delaware State Highway Department in 1935 as part of its expanded responsibilities for all former county roads and bridges. In 1946, the state highway department replaced the deteriorated concrete pivot pier with a timber pile pier. The repair plans note that the bridge was built in 1915, and that the swing span was opened about 100 times in 1946. The plans also show that there was a one-story frame operators house located on the northwest embankment.

The Poplar Street bridge was last opened to navigation in 1975. Since that time, it has undergone alterations that have rendered it inoperable but also have resulted in the preservation of the trusses and operating mechanism in situ. In 1994, the Delaware Department of Transportation removed the trusses to have them cleaned and painted. The beams that support and stabilize the bridge when it is opened were replaced in-kind. Original riveted connections were replaced by high strength bolts. The operating mechanism including gears, shafting, and center bearing were reset but not returned to operating condition.

Central Avenue *(Old US 13)* over Broad Creek *See map on page 95*

State Bridge S-152
Laurel, Sussex County
Designer/Builder: Scherzer Rolling Lift Bridge Company/Allen S. Fox

1923

The Central Avenue bridge is the oldest surviving bascule highway bridge in Delaware and it is one of two surviving Scherzer rolling lift bascule bridges in the state (the other is State Bridge K-21A). It was designed by the Scherzer Rolling Lift Bridge Company of Chicago and was built by contractor Allen S. Fox of Dayton, Ohio, under contract with the Delaware State Highway Department in 1923. The Central Avenue bridge has all of the characteristic features of the patented Scherzer design including rounded segmental girders that roll along steel tracks, thereby raising and low-

The Central Avenue bridge was the featured "Bridge of the Year" in the state highway department's 1924 Annual Report.

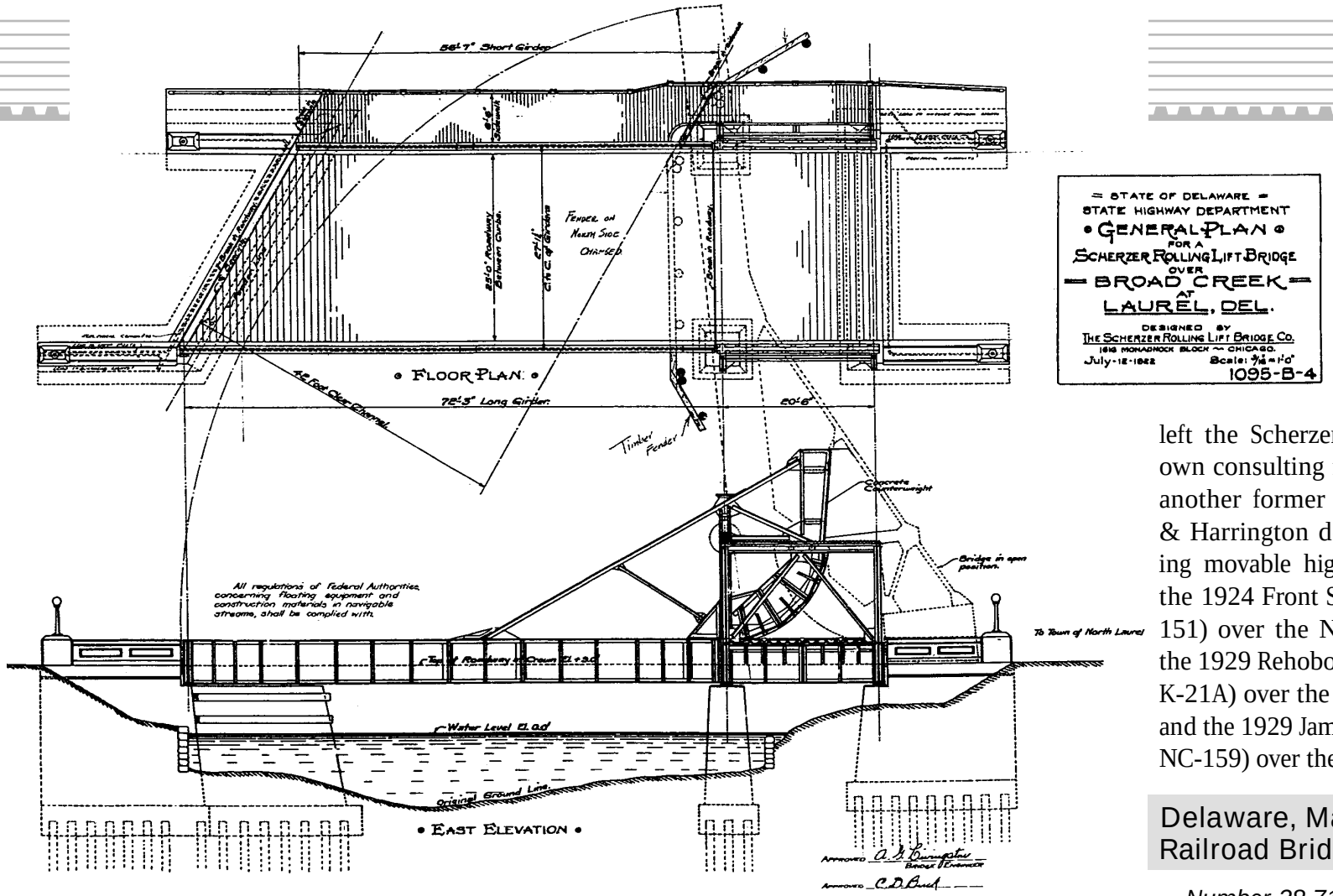
The Central Avenue bridge in Laurel is a patented Scherzer rolling lift bascule bridge, constructed in 1923.

In 1992, DelDOT rehabilitated the Central Avenue bridge. The floorbeams, stringers, and deck were replaced and the concrete abutments and wingwalls repaired. The electrical controls and operators house on the north embankment have been removed, and the bascule span currently is non-operational.

ering the bridge. The bridge was last opened in 1975, and it is currently non-operational. It is listed in the National Register as a contributing resource to the Laurel Historic District.

The two-span bridge consists of a single leaf, thru girder bascule span and a 20'-long steel thru girder approach span on the north end. The south end of the bascule leaf has a 20 degree skew, measuring 72'-long on the upstream side and 56'-long on the downstream side to accommodate a bend in the creek. The overhead concrete counterweight is supported on built-up towers. Although the electric motor, operators' house, and control systems have been removed, the open gear train and machinery platform over the roadway infront of the counterweight remain. The gear train activated the pinion gears engaging the straight open racks mounted on the stationary tower. When opened, the segmental girders rolled backward along the cast steel tracks mounted on top of the approach span. The counterweight moves to a position just above the surface of the deck.

The Central Avenue bridge was featured in the 1924 *Annual Report* of the state highway department as "the most notable bridge construction of the year." The account reported that the substructure design was prepared in-house, and bids with plans were received for the steel superstructure. Successful bidder for the project was the



General plans for the Central Avenue bridge. Note the dotted lines showing the position of the leaf in the open position; the concrete counterweight nearly touches the deck of the approach roadway.

Scherzer Rolling Lift Bridge Company. The bridge posed no unusual technical difficulties, so the company offered one of its standard-configuration rolling lift bascule bridges with overhead counterweight, a design that had been little changed since the early 1900s.

The Central Avenue bridge project initiated a fruitful association between the state highway department and Scherzer chief engineer Charles L. Keller, who subsequently left the Scherzer company to establish his own consulting firm with H. P. Harrington, another former Scherzer employee. Keller & Harrington designed three other surviving movable highway bridges in Delaware: the 1924 Front Street bridge (State Bridge S-151) over the Nanticoke River in Seaford; the 1929 Rehoboth Road bridge (State Bridge K-21A) over the Mispillion River in Milford, and the 1929 James Street bridge (State Bridge NC-159) over the Christina River in Newport.

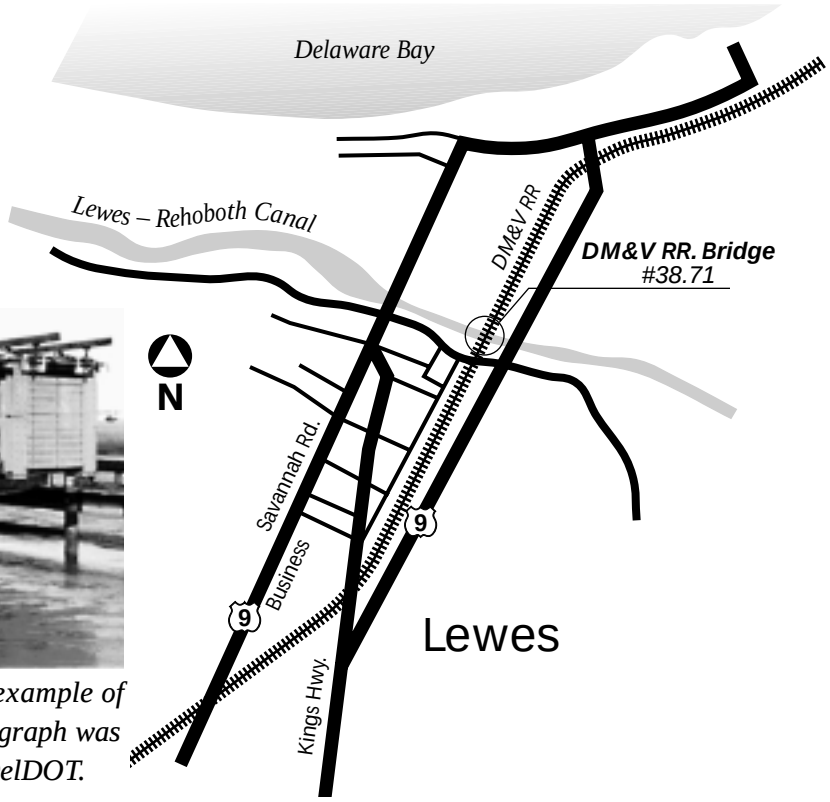
Delaware, Maryland & Virginia Railroad Bridge *(Lewes Railroad Bridge)*

Number 38.71
Georgetown-Lewes railroad line over Lewes-Rehoboth Canal
Lewes, Sussex County
Designer/Builder: DM&V Railroad

1916

The Delaware, Maryland & Virginia Railroad Bridge Number 38.71 carries the

The swing span bridge is opened manually by a capstan inserted in the bridge deck.



Georgetown-Lewes railroad line over the Lewes and Rehoboth Canal, 1/4-mile south of State Route 9 (Business) in Lewes. The bridge is a center-bearing, bobtail, swing span with an over all length of 92' and a deck width of about 17'. Constructed in 1916, the bridge is historically significant as a surviving example of a swing span railroad bridge.

The swing span bridge has a deck girder superstructure composed of two tapered, built-up girders. The design is called a bobtail swing span because of the unequal lengths of its two arms; the longer of the two arms measures about 60'-long, and the shorter about 30'-long. The end of the shorter arm is framed with a concrete counterweight for balance. Bobtail swing spans commonly were used for narrow waterways where the off-center pivot pier caused less of a channel obstruction. The abutments and pivot pier are concrete.

The Lewes bridge, built in 1916, is an example of a bobtail, swing span bridge. This photograph was taken prior to 1996 rehabilitation by DelDOT.

The bridge is operated manually by a capstan inserted in a drive shaft located in the deck. The capstan and drive shaft turn beveled open reduction gears that engage the pinion gear mounted on the pivot pier. The bridge rotates on its center bearing with eight balance wheels traveling on a track. A shaft operates a worm gear that moves two end wedges at the abutment end of the swing span's longer arm. In the closed position, the wedges lift the arm to afford a rigid support on the abutment and neutralize the end deflection of the arms. As with all movable railroad bridges, an important consideration is aligning the rails on the bridge with those of the approaching railroad tracks. To accomplish a secure fit, the rails on the ends of the bridge are bowed upwards by rail lift rods. After the bridge is closed, the operator engages a lever that lowers the rods, thus lowering

The Lewes bridge (left) is kept in the open position, and only closed two or three times per week for passing trains.

The rails on the ends of the bridge (above) are bowed upwards by rail lift rods, shown here. After the bridge is closed, the operator engages a lever that lowers the rods, thus lowering the rails into a slotted fitting with the approach tracks.

the rails into a slotted fitting with the approach tracks.

The Georgetown-Lewes rail line was established in 1869 as part of the Junction and Breakwater Railroad (J&B), a short line running from the Delaware Railroad at Harrington to the breakwater at Lewes. In 1883, the J&B was renamed the Delaware, Maryland & Virginia Railroad (DM&V) as part of the consolidation of several smaller Delmarva lines under the control of the Pennsylvania Railroad.

The DM&V spurred the development of fish oil processing near Cape Henlopen. These factories, located on the eastern side of the Lewes-Rehoboth Canal, were serviced by the DM&V, which made use of the swing span bridge to deliver their products. The line currently is owned by DelDOT and operated by the Maryland & Delaware Railroad.

The 1916 swing span bridge was erected as part of the construction of the Lewes-Rehoboth Canal, begun in 1912. The U.S. Army Corps of Engineers built the 12-mile long canal as part of the inland waterway. In the vicinity of Lewes, the canal followed the natural course of Lewes Creek, which was channelized to meet the canal specifications. In 1915, when the canal reached the existing railroad bridge over Lewes Creek, the DM&V submitted a proposal to the Corps to construct the swing span bridge. It was fabricated by the American Bridge Company at its Pencoyd, Pennsylvania shops.

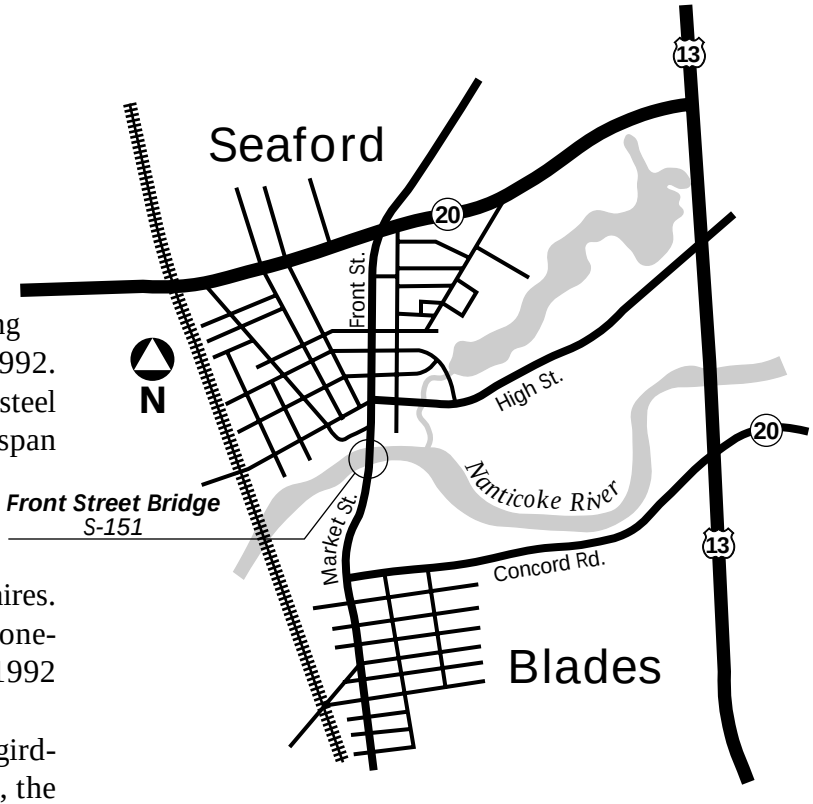
The Lewes bridge is one of three extant railroad swing span bridges in Sussex County. All are center bearing swing spans with deck girder superstructures. The oldest is the operational 1890 Delaware Railroad Bridge over the Nanticoke River in Seaford. The other is the non-operational 1911 Delaware Railroad Bridge over Broad Creek in Laurel.

Front Street *(Old US 13)* over Nanticoke River

State Bridge S-151
Seaford, Sussex County
Designer/Builder: Chicago Bascule Bridge Company (Keller & Harrington)/Allen S. Fox

1924-1925

The Front Street bridge is Delaware's oldest operating bascule highway bridge. Built in 1924-1925 under the auspices of the Delaware State Highway Department, the five span bridge consists of a 55'-long, single leaf bascule main span flanked at both ends by two, 33'-long prestressed box beam spans placed in 1992. They replaced the original encased steel multi girder approach spans. The main span is finished with pipe railings, and the approach spans have concrete balustrades. The end posts have concrete lamp posts with globe luminaires. At the north end of the bridge is the one-story frame operators house built in 1992 to replace the original.



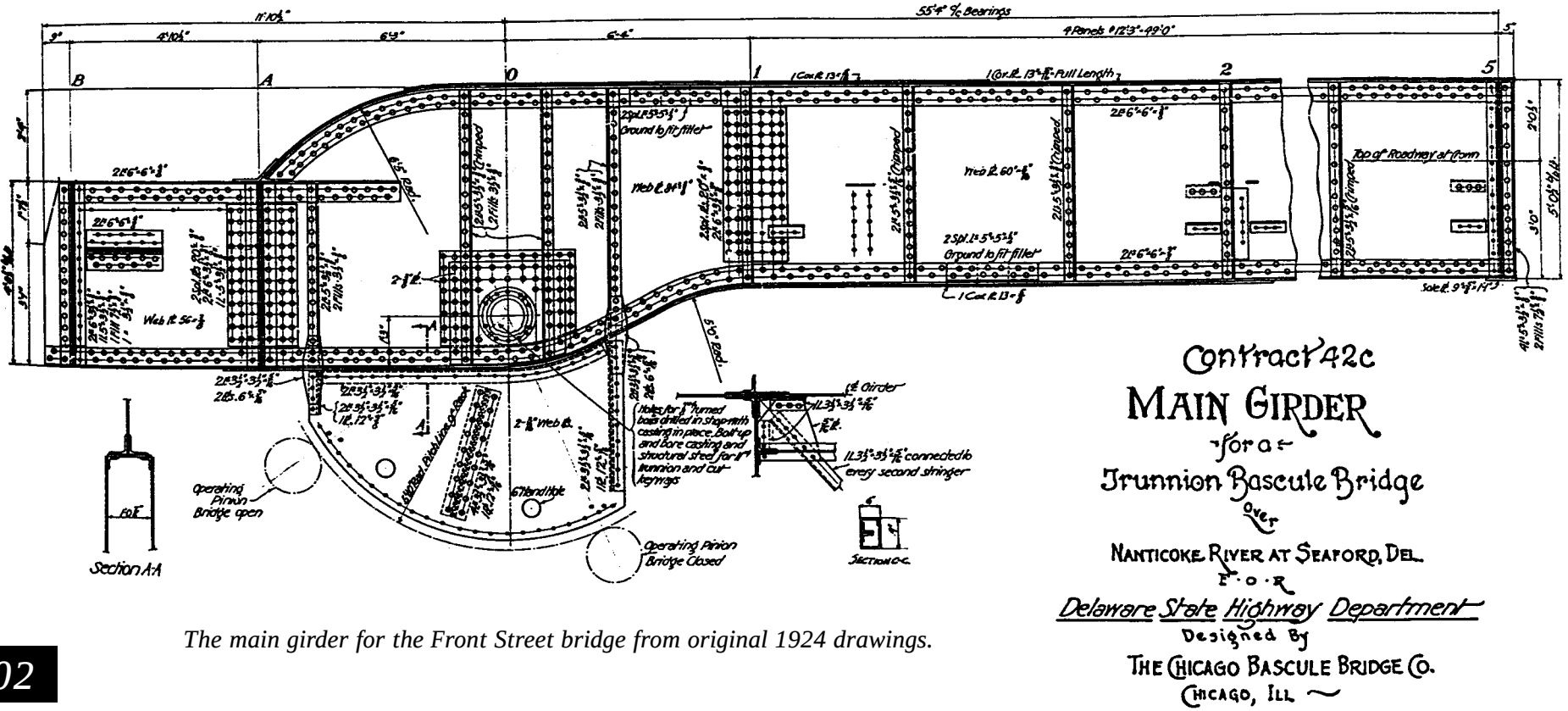
The movable leaf is a built-up thru girder with floorbeams. When in operation, the entire weight of the movable span is carried by trunnions in bearings placed near or at the center of gravity. They are supported on built up columns or towers that transfer loads to the substructure. The counterweight is attached to the heel end over the concrete counterweight pit. The counterweight maintains the leaf in equilibrium, thereby minimizing the amount of power needed to overcome the friction and inertia of the system. The electric motor-driven operating mechanism of shafting and open reduction gear sets engages the pinion gear and segmental rack bolted to the bottom of each bascule girder beneath the trunnion, thereby causing the leaf to pivot on the trunnion.

The Front Street bridge replaced a metal truss swing span bridge. In 1923, the Delaware State Highway Department contracted with the Chicago Bascule Bridge Company for the design work, but corre-

The 1924 Front Street bridge over the Nanticoke River in Seaford is Delaware's oldest operable simple trunnion bascule highway bridge. This photo was taken in 1988. DelDOT replaced the approach spans and rehabilitated the bascule operating mechanism in 1992.

spondence in the state's project files indicates that Charles L. Keller and H. P. Harrington, consulting engineers also of Chicago, actually prepared the designs. In 1923, Keller and Harrington had left the Scherzer Rolling Lift Bridge Company, and it seems likely that the Chicago Bascule Bridge Company simply handled the contract for them. Construction contractors were Imach-Wozny-McCoy, Inc. of Baltimore for the substructure, and Allen S. Fox of Dayton, Ohio for the superstructure.

In 1992, DelDOT rehabilitated the Front Street bridge. Work on the bascule span in-



The main girder for the Front Street bridge from original 1924 drawings.

The Rehoboth Road Bridge is a Scherzer rolling lift bascule bridge, constructed in 1929. This photograph was taken after the bridge's rehabilitation in 1996.

cluded a new concrete deck and repairs to the steel superstructure. The operating mechanism was overhauled with new motor, brake, and bearings installed, and most of the original open gear sets cleaned and reused in their original configuration. The concrete balustrades on the new approach spans were designed to match the originals. Although much of the bridge's fabric is replacement material, the operation, outward appearance, and function of the simple trunnion bascule bridge remains as per its original design.

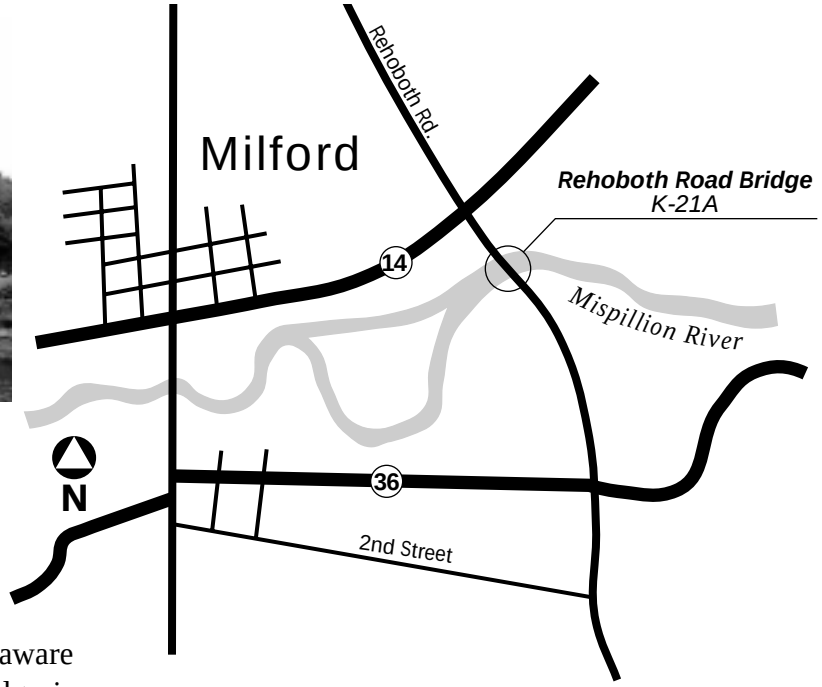
Rehoboth Road *(State Route 1 Business)* over Mispillion River

State Bridge K-21A
Milford, Kent County
Designer/Builder: Keller & Harrington/Bethlehem Steel Company

1929-1930

The Rehoboth Road bridge, a Scherzer rolling lift bascule bridge, was designed in 1929 by Keller & Harrington, consulting engineers from Chicago, under contract with the Delaware State Highway Department. The bridge is an example of the rolling lift bridge patented by William Scherzer in 1893, and refined in the late 1890s and early 1900s by the Scherzer Rolling Lift Bridge Company of Chicago. The Rehoboth Road bridge was built after the Scherzer company's basic patents had expired, and former employees Charles L. Keller and H. P. Harrington had branched off on their own.

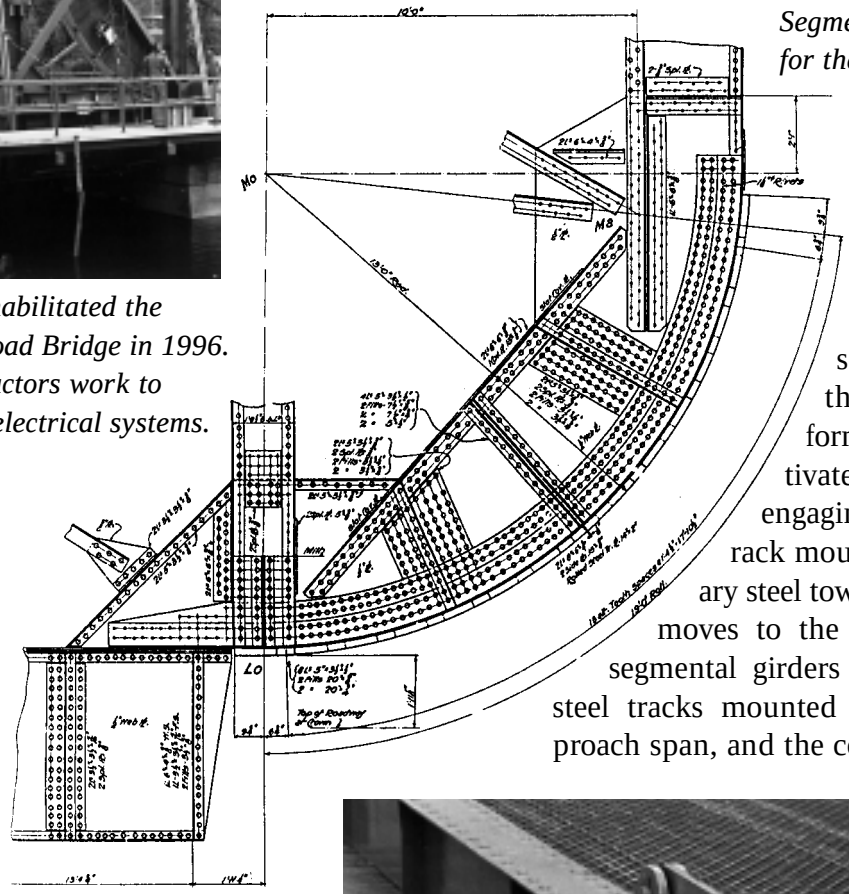
The three span bridge has a 56'-long, single leaf movable main span, flanked by two 26'-long steel thru girder spans supported on concrete abutments and piers. The main span is also a thru girder with



floorbeams. A timber sidewalk with pipe railings is cantilevered from the west side. The overhead concrete counterweight is supported by built-up column towers. The bridge is a downstate Delaware landmark, and is recognized by most local residents as the bridge with the words "Mispillion River" painted on the counterweight.

The Rehoboth Road bridge is operable, unlike its nearly identical but inoperable counterpart, the 1923 Central Avenue Bridge in Laurel (State Bridge S-152). The operating mechanism including electric

DelDOT rehabilitated the Rehoboth Road Bridge in 1996. Here, contractors work to install new electrical systems.



Segmental girder from original drawings for the Rehoboth Road Bridge, 1929.

motor, shafting, and open reduction gear sets are located on the machinery platform. The gear train activates the pinion gear engaging the straight open rack mounted on the stationary steel tower. When the bridge moves to the open position, the segmental girders roll along the cast steel tracks mounted on top of the approach span, and the counterweight comes to rest just above the surface of the deck. The gear train was replaced with all new gears, shafts, and bearings in 1996. The bridge's operation has remained the same, although the secondary reduction gears are a slightly different arrangement than the original. The frame operator's house on the north side of the bridge was constructed in 1996, replacing the original one. The control panel, electric wiring, and automated traffic signals are new. Also, as part of the 1996 rehabilitation, the floorbeams and stringers were replaced, and the girders were strengthened.

The bridge's toe lock is a simple lever, held in place with a pin.

The bridge was built in 1929 as part of a Delaware State Highway Department federal-aid project designed to relieve the congested streets of Milford's central business district. Rehoboth Road bypassed Milford on the east side of town and offered an alternative route for increasing traffic to downstate beach resorts. The bypass project highlighted the important role federal

The North Church Street Bridge is a single leaf bascule span built in 1932.

financial assistance played in the state highway department's program of modernization. The Rehoboth Road bridge offered no unusual technical challenges, and Keller & Harrington provided the state highway department with a design typical of many short-span Scherzer rolling lift bridges from the mid 1900s through the 1930s. Contractor for the steel superstructure fabrication was the Bethlehem Steel Company.

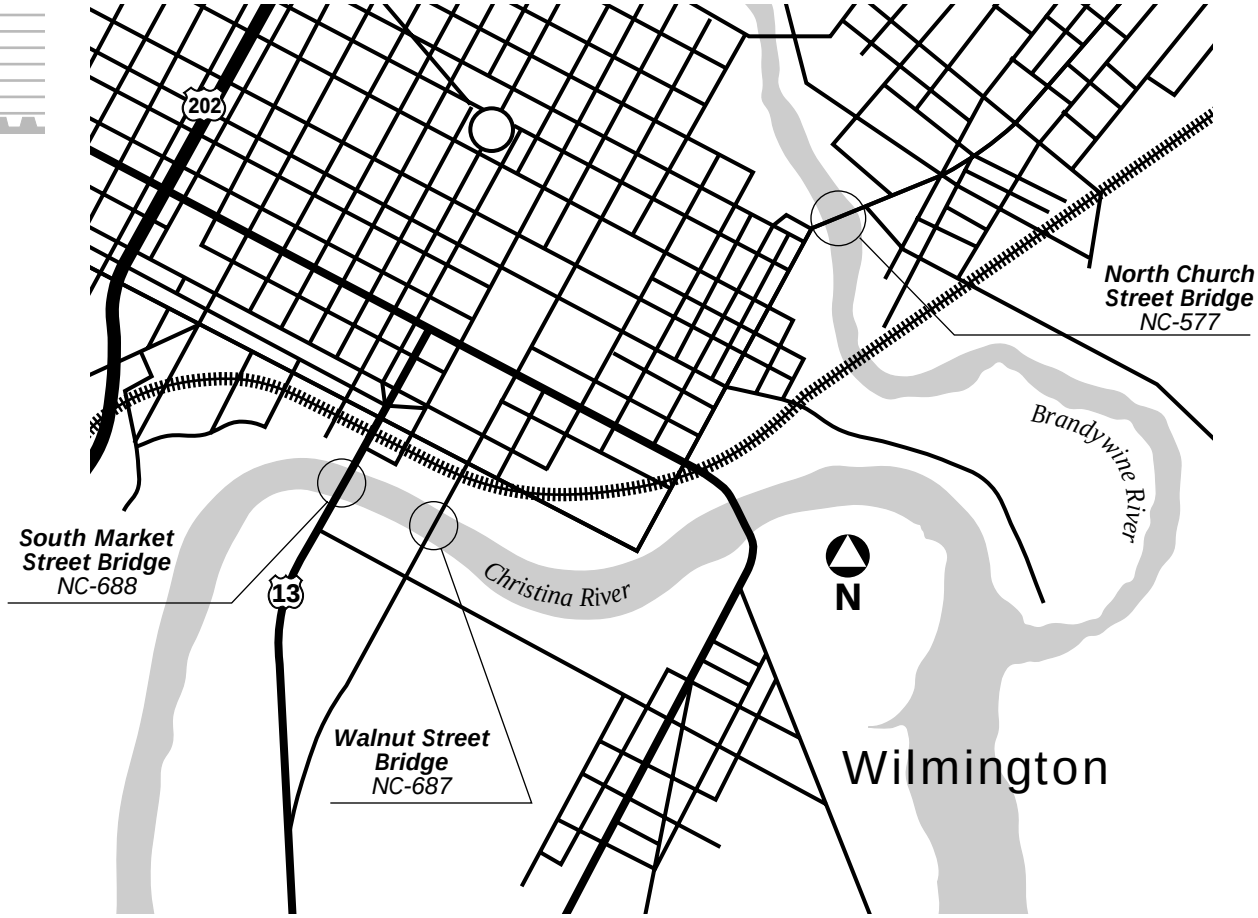
North Church Street over Brandywine River *See map on page 21*

State Bridge NC-577
Wilmington, New Castle County
Designer/Builder: Ash, Howard, Needles & Tammen/Seeds and Derham

1932

The North Church Street bridge is a simple trunnion bascule bridge erect-

The North Church Street bridge's operator's house was built of light-grey brick "to match the color of the finished concrete surfaces" of the Moderne-style bridge. Although original windows and doors have been replaced and operating equipment removed for over 40 years, the operator's house still remains an attractive feature of the bridge.



ed in 1932. It was designed by consulting engineers Ash, Howard, Needles & Tammen (AHN&T) of Kansas City and New York and erected by Seeds and Derham of Philadelphia, under contract with the Delaware State Highway Department and the Levy Court of New Castle County. Other contractors for the North Church Street Bridge were the Concrete Steel Company of Philadelphia, for reinforcing steel and the American Bridge Company of Ambridge, Pennsylvania, for structural steel fabrication.

The main span of the six-span, 332'-long, bridge is a single-leaf, simple trunnion bascule span. The bascule span is no longer operable. The bridge features Moderne-style architectural detailing. The concrete abutments, wingwalls, piers and balustrades are battered, stepped, and accented with vertical scoring. The operator's house is built of light grey brick and has a metal clad hipped roof. The five T-beam approach spans have arched fascia beams and are supported on concrete piers with ashlar-faced bases.

The North Church Street bridge replaced a metal drawbridge dating from 1869. The design contract was awarded to Ash, Howard, Needles & Tammen, a consulting engineer firm that specialized in movable bridges.

The North Church Street bridge had a short life as an operable movable bridge. In 1952, twenty years after completion, large-scale shipping on the Brandywine River had ended, and the Delaware State Highway Department received permission from the U.S. Army Corps of Engineers to close the bridge. The original wood deck was replaced by a concrete deck, and the bascule span was fixed in place by removal of the end locks and replacement with fixed bearings. In 1957, the electrical equipment, including motors and controls were removed.

South Market Street over Christina River

State Bridge NC-688
Wilmington, New Castle County
Designer/Builder: Harrington, Howard & Ash

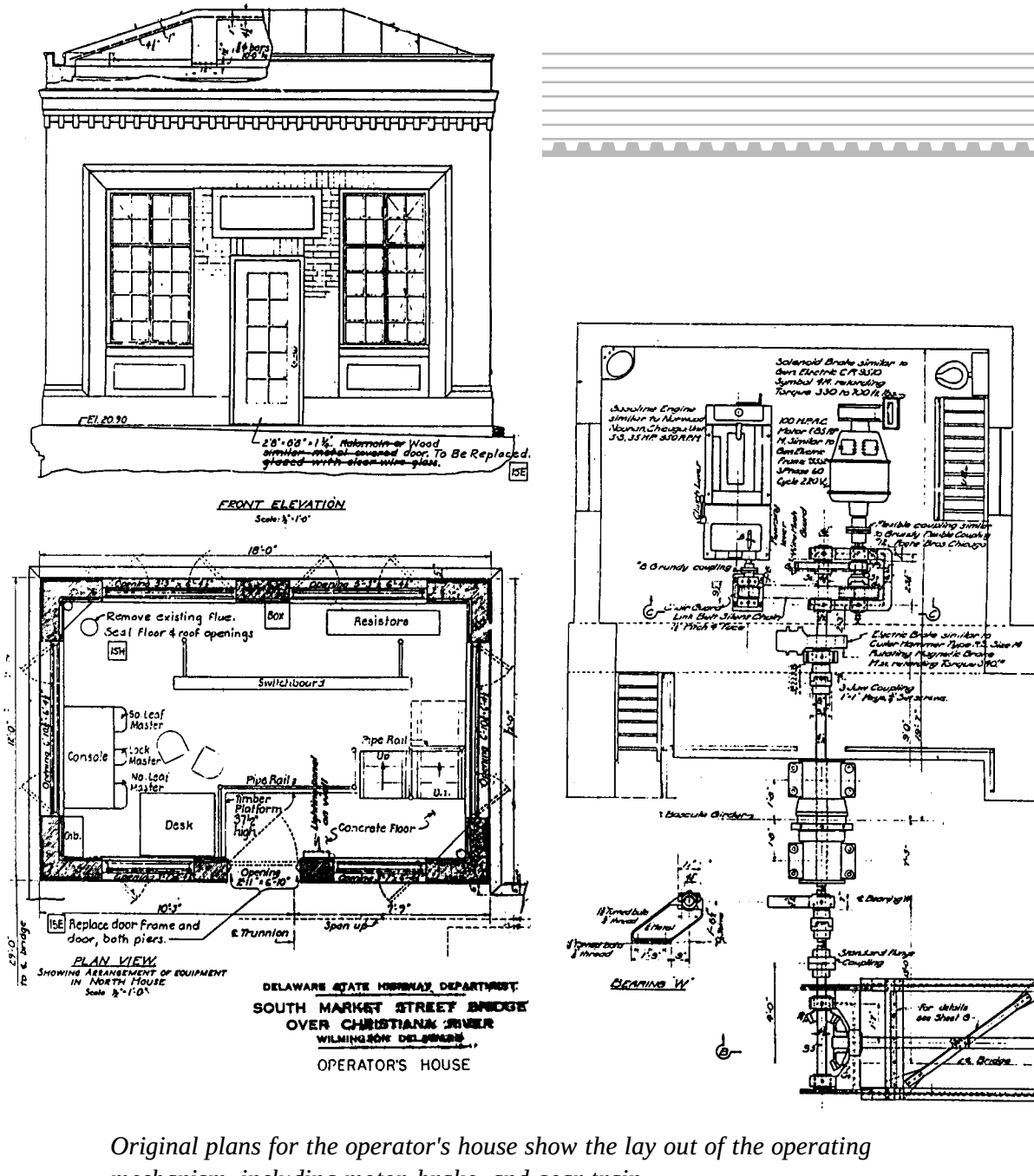
1927

The South Market Street bridge is a double-leaf bascule bridge designed by the prominent consulting engineering firm of Harrington, Howard & Ash of Kansas City and New York. The bridge was built in 1927 under the auspices of the Delaware State Highway Department. It is an example of the simple trunnion bascule design that had become by the mid 1920s the most common bascule bridge because of its relative economy and ease of operation and maintenance. The bridge is one of three pre-1957 simple trunnion bascule highway bridges that remain operable in Delaware.

The bridge consists of a 208'-long double-leaf bascule span, flanked by two steel

Construction photographs of the South Market Street Bridge from the Delaware State Highway Department's 1927 Annual Report.

The 1883 metal truss swing span bridge, shown in the background of this photo, continued to carry traffic while the new bascule bridge was constructed in 1927. The swing span was demolished after the new bridge opened in Fall 1927.



Original plans for the operator's house show the lay out of the operating mechanism, including motor, brake, and gear train.

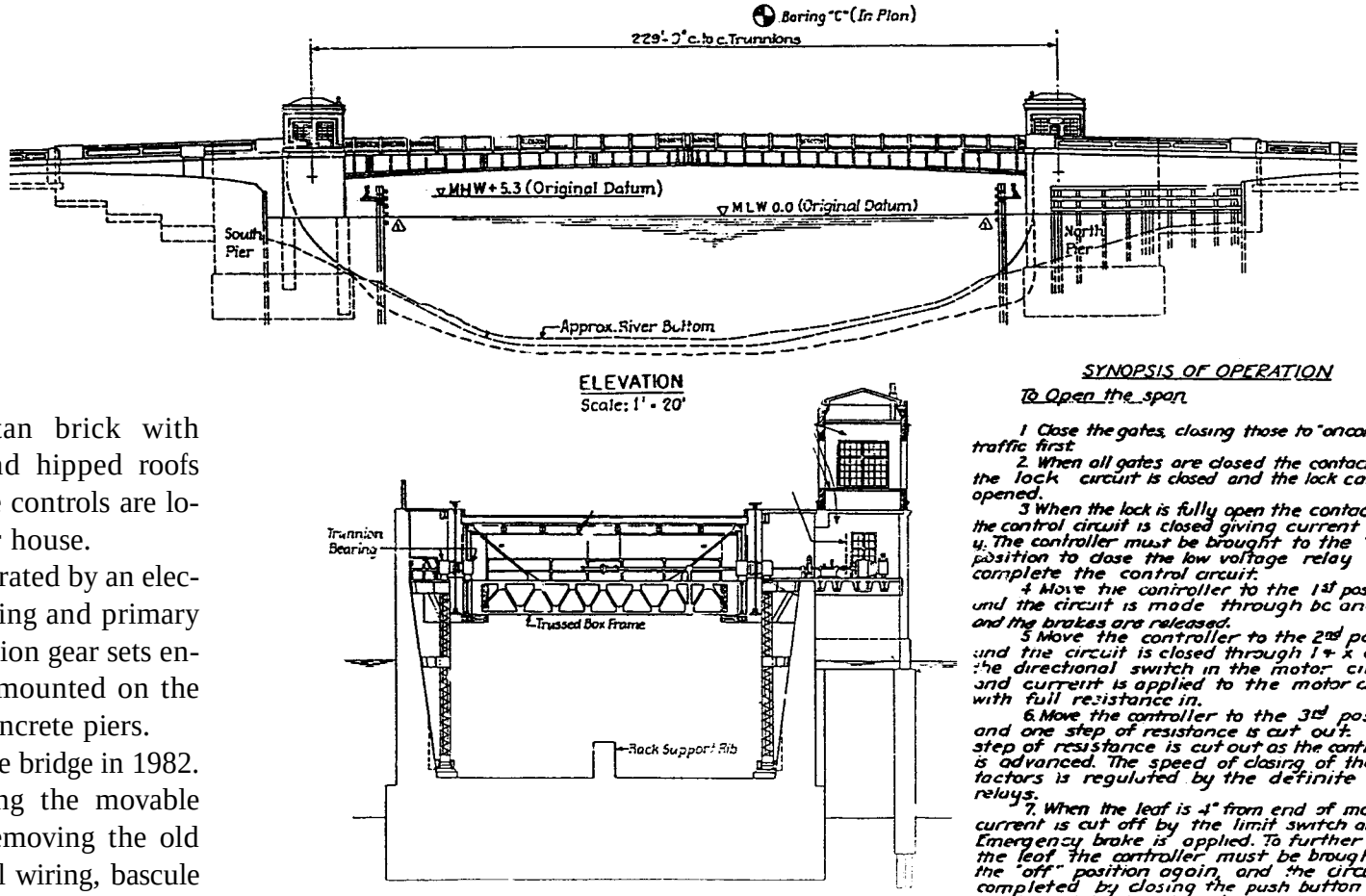
When a new South Market Street bridge was proposed in 1926, engineers Harrington, Howard & Ash prepared this rendering featured in the Delaware State Highway Department's Annual Report. Specifications for the design advised that "the design submitted should give careful consideration to architectural features as the bridge is used by all North and South traffic and a pleasing structure to the eye is desired."

deck girder spans that carry the approaches over the counterweight pits. The movable leaves are built-up thru girders with built-up floorbeams and stringers supporting an open steel grid deck. The 38'-wide bridge has cantilevered sidewalks finished with aluminum railings placed in 1982. The approach spans are finished with concrete parapets. At opposing corners of the bascule span are operator and machinery

houses constructed of tan brick with pressed metal cornices and hipped roofs behind plain parapets. The controls are located in the north operator house.

Each bascule leaf is operated by an electric motor that drives shafting and primary and secondary open reduction gear sets engaging a pinion and rack mounted on the inner curved face of the concrete piers.

DelDOT rehabilitated the bridge in 1982. Work included strengthening the movable girders and floorbeams; removing the old operator's console, electrical wiring, bascule motors and brakes, and replacing them with modern components; removing metal balustrades from the bascule span and replacing them with aluminum railings; and removing original center lock bars and replacing them with a new design center lock bar system.



The original drawings for the South Market Street bridge include a "Synopsis of Operation" listing the steps required of the bridge tender to open and close the bascule.

The South Market Street bridge is a 208'-long double-leaf bascule bridge, constructed in 1927.

Historically, the crossing of the Christina River at South Market Street has been a vital link connecting Wilmington with points south. In 1808, the Wilmington Bridge Company received a charter from the General Assembly to raise a private subscription of $15,000 to build a bridge to replace a ferry. The wooden "turn bridge" or swing span was in service until 1883 when the City of Wilmington replaced it with a metal truss swing span bridge. In 1926, the Delaware State Highway Department prepared a contract to replace the metal truss swing span, which was considered too narrow and light weight for existing traffic. The grand opening of the new South Market Street bascule bridge was Armistice Day, November 11, 1927. The bridge opening festivities were held in conjunction with a pageant and speeches.

The design of the South Market Street bridge was awarded to Harrington, Howard & Ash, a consulting engineer firm that specialized in movable bridges. The firm was founded in 1914 by John L. Harrington, Ernest E. Howard, and Louis R. Ash. In the late 1910s, Harrington, Howard & Ash's business grew rapidly, and the Kansas City-based firm established a branch office in New York in 1922. Head of the office was Enoch R. Needles (1888-1972), whose first large contract was to make surveys for a series of bridges over the Chesapeake & Delaware Canal. Enamored with the Delaware countryside, Needles bought a farm in New Castle County, and became a neighbor and friend of Francis duPont, the state's highway commissioner. The South Market Street bridge was the firm's first major contract for the Delaware State Highway Department, but not the last. The firm, which changed its name to Howard, Needles, Tammen & Bergendorff in 1941, has had a significant influence on the course of Delaware's transportation history. They designed the Delaware Memorial Bridge (1951, 1968) and the Delaware Turnpike/I-95 (1961-1964), along with numerous other bridges, turnpikes, and interstate highways across the nation.

Walnut Street over Christina River *See map on page 106*

State Bridge NC- 687
Wilmington, New Castle County
Designer/Builder: Parsons, Brinckerhoff, Hall & MacDonald/A. S. Wikstrom, Inc.

1954-1957

The Walnut Street bridge over the Christina River in Wilmington is the

The Walnut Street (left) bridge, looking north towards Wilmington.

The Walnut Street bridge (below), constructed from 1954 to 1957, is a double-leaf bascule bridge.

largest of Delaware's eight extant pre-1956 bascule highway bridges and is one of only three bascule bridges that remains operational. It is a simple trunnion bascule type. In 1955, the Delaware State Highway Department's *Annual Report* commented that the Walnut Street bridge was its "outstanding project for 1954-55." The bridge, among the largest bridge projects undertaken by the department in the decade after World War II, was designed specifically to address Wilmington's congestion problems. It provided an alternative route south from the city to US 13 and the Delaware Memorial Bridge.

The eight-span bridge consists of a 276'-6" double-leaf bascule main span flanked by three steel multi-girder approach spans to the north and four steel multi-girder approach spans to the south. The bridge has a steep vertical profile, achieving a vertical clearance of over 21' above mean high water level of the channel. The deck measures 64'-wide accommodating four traffic lanes and two sidewalks with three-high rail met-

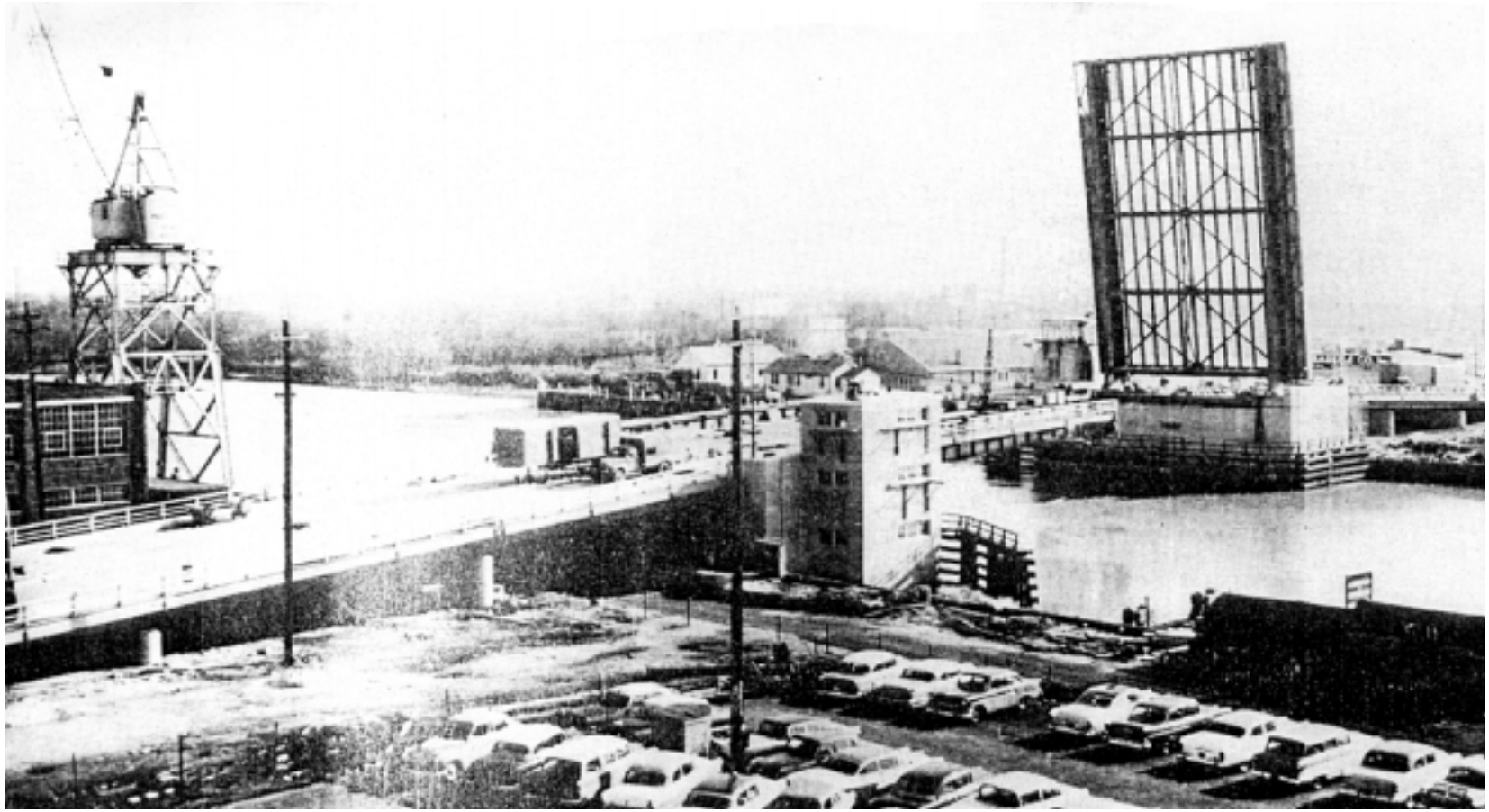
al railings. The bridge is supported on concrete piers accented with vertical scoring. Timber pile fenders protect the piers.

Despite its size, technologically speaking, the Walnut Street bridge was not innovative for its time. Rather, it is representative of the bascule bridge technology in widespread use by the 1910s. The Walnut Street bridge does, however, make use of such mid-20th century refinements as automated controls and signals, enclosed reduction gears, and electrically operated center lock bars.

The movable leaves are operated by a pinion gear engaging a segmental rack mounted to the bottom of the girders. Shafting and enclosed reduction gear sets transmit power from electric motors located on the first level of the operator's houses. Each leaf consist of two haunched built-up steel thru girders with built-up floorbeams, steel I-beam stringers, and an open-grid steel deck. The concrete counterweights are fixed in steel frames at the heel ends of the movable spans. The leaves are locked in the closed position by automated center locks located on the exterior of the main bascule girders.

Moderne-style, flat roofed reinforced concrete operater's houses finished with scoring in a checkerboard pattern are located at opposite ends of the movable span. They have horizontally pivoted steel sash windows. The three-story house at the northwest corner has a door at roadway deck level providing access to the lower level and machinery rooms. The four-story operator's house at the southeast corner contains the operator's console and electrical control equipment. The console is located on the top level, which has ribbon windows on three sides providing maximum visibility for the bridge operator.

Planning for the Walnut Street bridge began in 1952 when the Delaware State Highway Department recognized the need for improved highway access between Wilmington and points south including the newly opened Delaware Memorial Bridge near New Castle. In order to alleviate growing traffic problems and congestion on the South Market Street bridge (State Bridge NC-688), the department advocated for a new river crossing on a 3/4-mile long southern extension of Walnut Street. The project was to be funded in part by federal aid designated for use on urban highways. The department retained consulting engineers, Parsons, Brinckerhoff, Hall and MacDonald of New York to study alternative designs. The firm, chosen because of their nationally recognized expertise with urban expressways and large bridges, initially proposed a limited access expressway with high-level fixed span bridge over the Christina River, thus eliminating delays from bridge openings. That plan was passed over by the department because of the state legislature's unwillingness to supported limited-access highway legislation and the high cost of land-acquisition associated with extending the expressway over the tracks of the nearby Pennsylvania Railroad and into downtown Wilmington. The more economical option, with a movable bridge



In late 1956, as the Walnut Street bridge (above) neared completion, the south leaf was raised while contractors work on placing the deck of the north leaf. This view was taken from the Pennsylvania Railroad Station office building.

over the river and an underpass beneath the railroad, was chosen.

Construction began in June, 1954, and it was completed in May, 1957. Richard S. M. Lee, was the designing engineer, and J. C. Whiteman, Jr., was resident engineer. The primary contractor was A. S. Wikstrom, Inc. of Skaneateles, New York with the American Bridge Company of Ambridge, Pennsylvania providing the structural steel and the Earle Gear and Machine Company of Philadelphia providing the bascule machinery and gears. ■